8 ESTIMATION OF DISTANCE TO THE ENDPOINT FOR ALTERNATIVE SCENARIOS FOR TOXIC SUBSTANCES

In Chapter 8

- Reference tables of distances for alternative releases, including:
  - -- Generic reference tables (Exhibit 4), and
  - -- Chemical-specific reference tables (Exhibit 5).
- Considerations include:
  - -- Gas density (neutrally buoyant or dense),
  - -- Duration of release (10 minutes or 60 minutes),
  - -- Topography (rural or urban).

For estimating consequence distances for alternative scenarios for toxic substances, this guidance provides four generic reference tables for neutrally buoyant gases and vapors and four for dense gases. The generic reference tables of distances (Reference Tables 14-21) are found at the end of Chapter 10. The generic tables and the conditions for which each table is applicable are described in Exhibit 4. Four chemical-specific tables also are provided for ammonia, chlorine, and sulfur dioxide. The chemical-specific reference tables follow the generic reference tables at the end of Chapter 10. These tables, and the applicable conditions, are described in Exhibit 5.

All the reference tables of distances for alternative scenarios were developed assuming D stability and a wind speed of 3.0 meters per second (6.7 miles per hour) as representative of likely conditions for many sites. Many wind speed and atmospheric stability combinations may be possible at different times in different parts of the country. If D stability and 3.0 meters per second are not reasonable conditions for your site, you may want to use other methods to estimate distances.

For simplicity, this guidance assumes ground level releases. This guidance, therefore, may overestimate the consequence distance if your alternative scenario involves a release above ground level, particularly for neutrally buoyant gases and vapors. If you want to assume an elevated release, you may want to consider other methods to determine the consequence distance.

The generic reference tables should be used for all toxic substances other than ammonia, chlorine, and sulfur dioxide. To use the generic reference tables, you need to consider the release rates estimated for gases and evaporation from liquid pools and the duration of the release. For the alternative scenarios, the duration of toxic gas releases may be longer than the 10 minutes assumed for the worst-case analysis for gases. You need to determine the appropriate toxic endpoint and whether the gas or vapor is neutrally buoyant or dense, using the tables in Appendix B and considering the conditions of the release. You may interpolate between entries in the reference tables.

Exhibit 4
Generic Reference Tables of Distances for Alternative Scenarios

Applicable Conditions			Reference Table Number
Gas or Vapor Density	**Topography**	**Release Duration (minutes)**	
Neutrally buoyant	Rural	10	14
		60	15
	Urban	10	16
		60	17
Dense	Rural	10	18
		60	19
	Urban	10	20
		60	21

Exhibit 5
Chemical-Specific Reference Tables of Distances for Alternative Scenarios

Substance	Conditions of Release			Reference Table Number
	Gas or Vapor Density	**Release Duration (minutes)**	**Topography**	
Anhydrous ammonia liquefied under pressure	Dense	10-60	Rural, urban	22
Non-liquefied ammonia, ammonia liquefied by refrigeration, or aqueous ammonia	Neutrally buoyant	10-60	Rural, urban	23
Chlorine	Dense	10-60	Rural, urban	24
Sulfur dioxide (anhydrous)	Dense	10-60	Rural, urban	25

Note the following concerning the use of the chemical-specific reference tables for ammonia, chlorine, and sulfur dioxide:

- The table for anhydrous ammonia (Reference Table 22) applies only to flashing releases of ammonia liquefied under pressure. Use Table 23 for release of ammonia as a gas (e.g., evaporation from a pool or release from the vapor space of a tank).

- You may use these tables for releases of any duration.

To use the reference tables of distances, follow these steps:

For Regulated Toxic Substances Other than Ammonia, Chlorine, and Sulfur Dioxide

- Find the toxic endpoint for the substance in Appendix B (Exhibit B-1 for toxic gases or Exhibit B-2 for toxic liquids).

- Determine whether the table for neutrally buoyant or dense gases and vapors is appropriate from Appendix B (Exhibit B-1 for toxic gases or Exhibit B-2, column for alternative case, for toxic liquids). A toxic gas that is lighter than air may behave as a dense gas upon release if it is liquefied under pressure, because the released gas may be mixed with liquid droplets, or if it is cold. Consider the state of the released gas when you decide which table is appropriate.

- Determine whether the table for rural or urban conditions is appropriate.

  -- Use the rural table if your site is in an open area with few obstructions.

  -- Use the urban table if your site is in an urban or obstructed area.

- Determine whether the 10-minute table or the 60-minute table is appropriate.

  -- Use the 10-minute table for releases from evaporating pools of common water solutions and of oleum.

  -- If you estimated the release duration for gas release or pool evaporation to be 10 minutes or less, use the 10-minute table.

  -- If you estimated the release duration for gas release or pool evaporation to be more than 10 minutes, use the 60-minute table.

Neutrally Buoyant Gases or Vapors

- If Exhibit B-1 or B-2 indicates the gas or vapor should be considered neutrally buoyant, and other factors would not cause the gas or vapor to behave as a dense gas, divide the estimated release rate (pounds per minute) by the toxic endpoint (milligrams per liter).

- Find the range of release rate/toxic endpoint values that includes your calculated release rate/toxic endpoint in the first column of the appropriate table (Reference Table 14, 15, 16, or 17), then find the corresponding distance to the right.

Dense Gases or Vapors

- If Exhibit B-1 or B-2 or consideration of other relevant factors indicates the substance should be considered a dense gas or vapor (heavier than air), find the distance in the appropriate table (Reference Table 18, 19, 20, or 21) as follows;

  -- Find the toxic endpoint closest to that of the substance by reading across the top of the table. If the endpoint of the substance is halfway between two values on the table, choose the value on the table that is smaller (to the left). Otherwise, choose the closest value to the right or the left.

  -- Find the release rate closest to the release rate estimated for the substance at the left of the table. If the calculated release rate is halfway between two values on the table, choose the release rate that is larger (farther down on the table). Otherwise, choose the closest value (up or down on the table).

  -- Read across from the release rate and down from the endpoint to find the distance corresponding to the toxic endpoint and release rate for your substance.

For Ammonia, Chlorine, or Sulfur Dioxide

- Find the appropriate chemical-specific table for your substance (see the descriptions of Reference Tables 22-25 in Exhibit 5).

  -- If you have ammonia liquefied by refrigeration alone, you may use Reference Table 23, even if the duration of the release is greater than 10 minutes.

  -- If you have chlorine or sulfur dioxide liquefied by refrigeration alone, you may use the chemical-specific reference tables, even if the duration of the release is greater than 10 minutes.

- Determine whether rural or urban topography is applicable to your site.

  -- Use the rural column in the reference table if your site is in an open area with few obstructions.

  -- Use the urban column if your site is in an urban or obstructed area.

- Estimate the consequence distance as follows:

  -- In the left-hand column of the table, find the release rate closest to your calculated release rate.

-- Read the corresponding distance from the appropriate column (urban or rural) to the right.

The development of the generic reference tables is discussed in Appendix D, Sections D.4.1 and D.4.2. The development of the chemical-specific reference tables is discussed in industry-specific risk management program guidance documents and a backup information document that are cited in Section D.4.3. If you think the results of the method presented here overstate the potential consequences of a your alternative release scenario, you may choose to use other methods or models that take additional site-specific factors into account.

Examples 24 and 25 below include the results of modeling using two other models, ALOHA and WHAZAN, for comparison with the results of the methods presented in this guidance. Appendix D, Section D.4.5 provides additional information on this modeling.

Example 24. Gas Release of Chlorine

Assume that you calculated a release rate of 500 pounds per minute of chlorine from a tank. A chemical-specific table is provided for chlorine, so you do not need to consult Appendix B for information on chlorine. The topography of your site is urban. For a release of chlorine under average meteorology (D stability and 3 meters per second wind speed), go to Reference Table 24. The estimated release rate of 500 pounds per minute, with urban topography, corresponds to a consequence distance of 0.4 miles.

Additional Modeling for Comparison

The ALOHA model gave a distance of 3.0 miles to the endpoint, using the same assumptions.

The WHAZAN model gave a distance of 3.2 miles to the endpoint, using the same assumptions and the dense cloud dispersion model.

Example 25. Allyl Alcohol Evaporating from Pool

In Example 23, the evaporation rate of allyl alcohol from a pool was calculated as 63 pounds per minute. The total quantity in the pool was estimated as 9,830 pounds; therefore, the pool would evaporate in 9,830/63 or 156 minutes. You would use a 60-minute reference table to estimate the distance to the endpoint. From Exhibit B-2 in Appendix B, the toxic endpoint for allyl alcohol is 0.036 mg/L, and the appropriate reference table for the alternative scenario analysis is a neutrally buoyant plume table. To find the distance from the neutrally buoyant plume tables, you need the release rate divided by the endpoint. In this case, it is 63/0.036, or 1,750. Assuming the release takes place in a rural location, you use Reference Table 15, applicable to neutrally buoyant plumes, 60-minute releases, and rural conditions. From this table, you estimate the distance as 0.4 mile.

Additional Modeling for Comparison

The ALOHA model gave a distance of 0.7 mile to the endpoint for a release rate of 63 pounds per minute, using the same assumptions and the dense gas model.

The WHAZAN model gave a distance of 0.5 mile to the endpoint for a release rate of 63 pounds per minute, using the same assumptions and the buoyant plume dispersion model.